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(12) **United States Patent**
Cumming

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(54) **INTRAOCULAR LENS**

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This patent is subject to a terminal disclaimer.

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A61F 2/16 (2006.01)

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CPC ***A61F 2/1629*** (2013.01); ***A61F 2/1624*** (2013.01); *A61F 2002/1682* (2015.04)

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CPC ... A61F 2/1613; A61F 2/1624; A61F 2/1629; A61F 2/1635; A61F 2/1637; A61F 2/1648; A61F 2002/1681; A61F 2002/1689; A61F 2002/1697; A61F 2002/1682
USPC 623/6.37–6.38, 6.43, 6.46, 6.56
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,834,023	A	5/1958	Lieb
4,073,014	A	2/1978	Poler
4,118,808	A	10/1978	Poler
4,122,556	A	10/1978	Poler
4,159,546	A	7/1979	Shearing
4,168,547	A	9/1979	Konstantinov et al.
4,173,798	A	11/1979	Welsh
4,174,543	A	11/1979	Kelman
4,206,518	A	6/1980	Jardon et al.
4,244,060	A	1/1981	Hoffer
4,254,509	A	3/1981	Tennant
4,277,851	A	7/1981	Choyce et al.
4,298,995	A	11/1981	Poler
4,304,012	A	12/1981	Richard
4,409,690	A	10/1983	Gess
4,409,691	A	10/1983	Levy

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2110184	A1	12/1992
CH	681687		5/1993

(Continued)

OTHER PUBLICATIONS

Dykstra, M., et al. Biological Electron Microscopy: Theory, Techniques, and Troubleshooting, 2003, p. 81.

(Continued)

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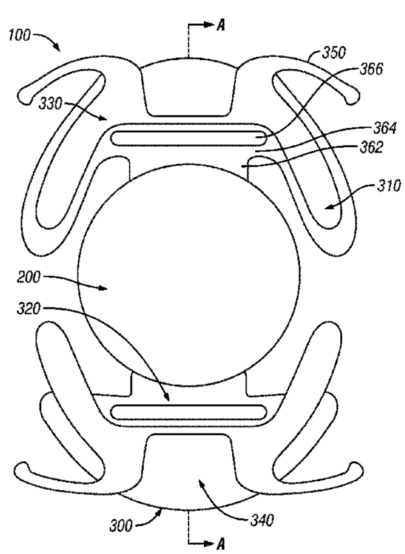
(57) **ABSTRACT**

An accommodating intraocular lens comprising a lens optic coupled to at least one haptic and a torsion bar positioned between the lens optic and the at least one haptic such that the torsion bar facilitates accommodation by deforming in response to a vitreous pressure change.

9 Claims, 1 Drawing Sheet



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,424,597	A	1/1984	Schlegel
4,441,217	A	4/1984	Cozean, Jr.
4,477,931	A	10/1984	Kelman
4,573,998	A	3/1986	Mazzocco
4,585,457	A	4/1986	Kalb
4,605,411	A	8/1986	Fedorov et al.
4,629,462	A	12/1986	Feaster
4,648,878	A	3/1987	Kelman
4,664,665	A	5/1987	Reuss et al.
4,664,666	A	5/1987	Barrett
4,673,406	A	6/1987	Schlegel
4,681,102	A	7/1987	Bartell
4,704,123	A	11/1987	Smith
4,710,195	A	12/1987	Glovinazzo
4,718,904	A	1/1988	Thornton
4,737,322	A	4/1988	Bruns et al.
4,738,680	A	4/1988	Herman
4,743,254	A	5/1988	Davenport
4,753,655	A	6/1988	Hecht
4,759,761	A	7/1988	Portnoy
4,763,650	A	8/1988	Hauser
4,765,329	A	8/1988	Cumming et al.
4,769,033	A	9/1988	Nordan
4,769,035	A	9/1988	Kelman
4,772,283	A	9/1988	White
4,778,463	A	10/1988	Hetland
4,781,719	A	11/1988	Kelman
4,790,847	A	12/1988	Woods
4,793,344	A	12/1988	Cumming et al.
4,813,955	A	3/1989	Achatz et al.
4,816,030	A	3/1989	Robinson
4,840,627	A	6/1989	Blumenthal
4,842,599	A	6/1989	Bronstein
4,842,601	A	6/1989	Smith
4,846,833	A	7/1989	Cumming
4,862,885	A	9/1989	Cumming
4,865,601	A	9/1989	Caldwell et al.
4,868,251	A	9/1989	Reich et al.
4,880,427	A	11/1989	Anis
4,888,012	A	12/1989	Horn et al.
4,892,543	A	1/1990	Turley
4,919,130	A	4/1990	Stoy et al.
4,932,966	A	6/1990	Christie et al.
4,932,968	A	6/1990	Caldwell et al.
4,932,970	A	6/1990	Portney
4,936,850	A	6/1990	Barrett
4,963,148	A	10/1990	Sulc et al.
4,969,897	A	11/1990	Kalb
4,976,716	A	12/1990	Cumming
4,978,354	A	12/1990	Van Gent
4,994,082	A	2/1991	Richards et al.
5,047,051	A	9/1991	Cumming
5,066,297	A	11/1991	Cumming
5,078,742	A	1/1992	Dahan
5,089,022	A	2/1992	Koester et al.
5,139,518	A	8/1992	White
5,141,507	A	8/1992	Paraekh
5,152,788	A	10/1992	Isaacson et al.
5,152,789	A	10/1992	Willis
5,171,319	A	12/1992	Keates et al.
5,171,320	A	12/1992	Nishi
5,180,390	A	1/1993	Drews
5,217,490	A	6/1993	Sayano et al.
5,275,604	A	1/1994	Rheinish et al.
5,275,623	A	1/1994	Sarfarazi
5,275,624	A	1/1994	Hara et al.
5,290,310	A	3/1994	Makower et al.
5,304,182	A	4/1994	Rheinish et al.
5,324,306	A	6/1994	Makower et al.
5,326,347	A	7/1994	Cumming
5,366,502	A	11/1994	Patel
5,376,115	A	12/1994	Jansen
5,425,734	A	6/1995	Blake
5,443,506	A	8/1995	Garabet
5,474,562	A	12/1995	Orchowski et al.
5,476,514	A	12/1995	Cumming
5,489,302	A	2/1996	Skottun
5,496,366	A	3/1996	Cumming
5,522,891	A	6/1996	Klaas
5,562,731	A	10/1996	Cumming
5,578,042	A	11/1996	Cumming
5,578,078	A	11/1996	Nakajima et al.
5,607,472	A	3/1997	Thompson
5,611,968	A	3/1997	Grisoni et al.
5,647,865	A	7/1997	Swinger
5,674,282	A	10/1997	Cumming
5,686,414	A	11/1997	Scannon
5,699,142	A	12/1997	Lee et al.
5,716,403	A	2/1998	Tran et al.
5,800,532	A	9/1998	Lieberman
5,837,156	A	11/1998	Cumming
5,843,187	A	12/1998	Bayers
5,873,879	A	2/1999	Figueroa et al.
5,919,230	A	7/1999	Sambursky
5,944,725	A	8/1999	Cicenas et al.
5,968,094	A	10/1999	Werblin et al.
5,984,914	A	11/1999	Cumming
6,007,579	A	12/1999	Lipshitz et al.
6,013,101	A	1/2000	Israel
6,015,435	A	1/2000	Valunin et al.
6,027,531	A	2/2000	Tassignon
6,051,024	A	4/2000	Cumming
6,066,171	A	5/2000	Lipshitz et al.
6,066,172	A	5/2000	Huo et al.
6,113,633	A	9/2000	Portney
6,129,760	A	10/2000	Fedorov et al.
6,161,544	A	12/2000	DeVore
6,164,282	A	12/2000	Gwon et al.
6,176,878	B1	1/2001	Gwon et al.
6,179,870	B1	1/2001	Sourdille et al.
6,193,750	B1	2/2001	Cumming
6,197,058	B1	3/2001	Portney
6,197,059	B1	3/2001	Cumming
6,217,612	B1	4/2001	Woods
6,299,641	B1	10/2001	Woods
6,302,911	B1	10/2001	Hanna
6,322,589	B1	11/2001	Cumming
6,342,073	B1	1/2002	Cumming et al.
6,387,126	B1	5/2002	Cumming
6,391,056	B2	5/2002	Cumming
6,406,494	B1	6/2002	Laguette et al.
6,409,763	B1	6/2002	Brady
6,413,276	B1	7/2002	Werblin
6,419,697	B1	7/2002	Kelman
6,423,094	B1	7/2002	Sarfarazi
6,443,985	B1	9/2002	Woods
6,451,056	B1	9/2002	Cumming
6,461,384	B1	10/2002	Hoffmann et al.
6,488,708	B2	12/2002	Sarfarazi
6,494,911	B2	12/2002	Cumming
6,497,708	B1	12/2002	Cumming
6,503,275	B1	1/2003	Cumming
6,503,276	B2	1/2003	Lang et al.
6,517,577	B1	2/2003	Callahan et al.
6,524,340	B2	2/2003	Israel
6,540,353	B1	4/2003	Dunn
6,558,420	B2	5/2003	Green
6,613,343	B2	9/2003	Dillingham et al.
6,616,691	B1	9/2003	Tran
6,616,692	B1	9/2003	Glick et al.
6,638,305	B2	10/2003	Laguette
6,638,306	B2	10/2003	Cumming
6,645,245	B1	11/2003	Preussner
6,660,035	B1	12/2003	Lang et al.
6,660,036	B2	12/2003	Cumming
6,685,741	B2	2/2004	Landreville et al.
6,695,881	B2	2/2004	Peng et al.
6,749,634	B2	6/2004	Hanna
6,767,363	B1	7/2004	Bandhauer et al.
6,849,091	B1	2/2005	Cumming
6,858,040	B2	2/2005	Nguyen et al.
6,881,225	B2	4/2005	Okada
6,884,263	B2	4/2005	Valyunin
6,921,416	B2	7/2005	Khoury

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,926,736	B2	8/2005	Peng
6,932,839	B1	8/2005	Kamerling et al.
6,969,403	B2	11/2005	Peng
6,972,033	B2	12/2005	McNicholas
7,018,409	B2	3/2006	Glick
7,025,783	B2	4/2006	Brady
7,037,338	B2	5/2006	Nagamoto
7,048,760	B2	5/2006	Cumming
7,097,660	B2	8/2006	Portney
7,125,422	B2	10/2006	Woods et al.
7,150,759	B2	12/2006	Paul et al.
7,150,760	B2	12/2006	Zhang
7,229,475	B2	6/2007	Glazier
7,229,476	B2	6/2007	Azar
7,300,464	B2	11/2007	Tran
7,326,246	B2	2/2008	Brady
7,341,599	B1	3/2008	Peyman
7,435,258	B2	10/2008	Blake
7,435,259	B2	10/2008	Cumming
7,553,327	B2	6/2009	Cumming
7,662,180	B2	2/2010	Paul et al.
7,763,070	B2	7/2010	Cumming
7,837,730	B2	11/2010	Cumming
7,981,155	B2	7/2011	Cumming
7,985,253	B2	7/2011	Cumming
8,038,711	B2	10/2011	Clarke
8,080,056	B2	12/2011	Cumming
8,100,965	B2	1/2012	Cumming et al.
8,109,998	B2	2/2012	Cumming
8,163,015	B2	4/2012	Cumming
8,216,308	B2	7/2012	Blake et al.
8,388,608	B1	3/2013	Kaluzna
8,523,942	B2	9/2013	Cumming
8,734,512	B2	5/2014	Cumming
8,764,823	B2	7/2014	Cumming
9,034,036	B2	5/2015	Cumming
2001/0001836	A1	5/2001	Cumming
2002/0120329	A1	8/2002	Lang et al.
2002/0138140	A1	9/2002	Hanna
2003/0060881	A1	3/2003	Glick et al.
2003/0078658	A1	4/2003	Zadno-Azizi
2003/0097177	A1	5/2003	Tran
2003/0109925	A1	6/2003	Ghazizadeh et al.
2003/0135272	A1	7/2003	Brady et al.
2003/0142269	A1	7/2003	Cumming
2003/0171808	A1	9/2003	Phillips
2003/0171809	A1	9/2003	Phillips
2003/0187505	A1	10/2003	Liao
2003/0199977	A1	10/2003	Cumming
2003/0204257	A1	10/2003	Southard
2004/0002757	A1	1/2004	Lai et al.
2004/0015236	A1	1/2004	Sarfarazi
2004/0082993	A1	4/2004	Woods
2004/0082994	A1	4/2004	Woods et al.
2004/0111152	A1	6/2004	Kelman
2004/0148023	A1	7/2004	Shu
2004/0215207	A1	10/2004	Cumming
2004/0220666	A1	11/2004	Cumming
2004/0243232	A1	12/2004	Cumming
2004/0249456	A1	12/2004	Cumming
2005/0021140	A1	1/2005	Liao
2005/0027354	A1	2/2005	Brady et al.
2005/0075732	A1	4/2005	Israel
2005/0096741	A1	5/2005	Cumming
2005/0107875	A1	5/2005	Cumming
2005/0125058	A1	6/2005	Cumming et al.
2005/0137703	A1	6/2005	Chen
2005/0267576	A1	12/2005	Cumming
2005/0288784	A1	12/2005	Peyman
2006/0064077	A1	3/2006	Peyman
2006/0064162	A1	3/2006	Klima
2006/0100704	A1	5/2006	Blake et al.
2006/0111776	A1	5/2006	Glick et al.
2006/0116764	A1	6/2006	Simpson
2006/0149369	A1	7/2006	Cumming et al.
2007/0021832	A1	1/2007	Nordan
2007/0032867	A1	2/2007	Cumming
2007/0129800	A1	6/2007	Cumming
2007/0129803	A1	6/2007	Cumming et al.
2007/0135915	A1	6/2007	Klima
2007/0142908	A1	6/2007	Xu
2007/0198084	A1	8/2007	Cumming et al.
2007/0244472	A1	10/2007	Kuhn et al.
2008/0027538	A1	1/2008	Cumming
2008/0027539	A1	1/2008	Cumming
2008/0027540	A1	1/2008	Cumming
2008/0046077	A1	2/2008	Cumming
2008/0086208	A1	4/2008	Nordan
2008/0154362	A1	6/2008	Cumming
2008/0281415	A1	11/2008	Cumming
2008/0281416	A1*	11/2008	Cumming 623/6.37
2008/0288066	A1	11/2008	Cumming
2008/0294254	A1	11/2008	Cumming et al.
2008/0319545	A1	12/2008	Cumming
2009/0005866	A1*	1/2009	Cumming 623/6.39
2009/0234449	A1	9/2009	De Juan, Jr. et al.
2009/0248154	A1	10/2009	Dell
2010/0004742	A1	1/2010	Cumming
2010/0057202	A1	3/2010	Bogaert
2011/0313519	A1	12/2011	Cumming
2011/0313524	A1	12/2011	Cumming
2011/0313525	A1	12/2011	Cumming
2011/0313526	A1*	12/2011	Cumming 623/6.44
2012/0296424	A1	11/2012	Betser
2013/0073039	A1	3/2013	Mirlay
2013/0231742	A1	9/2013	Deacon et al.
2014/0094909	A1	4/2014	Cumming
2014/0155871	A1	6/2014	Cumming
2014/0172093	A1	6/2014	Cumming
2015/0012088	A1	1/2015	Cumming
2015/0073550	A1	3/2015	Cumming
2015/0088254	A1	3/2015	Cumming
2015/0182327	A1	7/2015	Cumming
2015/0182328	A1	7/2015	Cumming
2015/0245904	A1	9/2015	Cumming
2015/0245905	A1	9/2015	Cumming

FOREIGN PATENT DOCUMENTS

DE	3626869	2/1988
FR	2728458	6/1996
FR	2728459	6/1996
FR	2734472	11/1996
FR	2765797	1/1999
FR	2991572	12/2013
GB	2171912	9/1986
GB	2226246	6/1990
JP	2003-190193	7/2003
SU	1123685	11/1984
WO	WO 93/05733	4/1993
WO	WO 01/19288	3/2001
WO	WO 01/19289	3/2001
WO	WO 03/017873	3/2003
WO	WO 2007/037180	4/2007
WO	WO 2009/048656	4/2009
WO	WO 2009/086511	7/2009
WO	WO 2011/151839	12/2011

OTHER PUBLICATIONS

International Search Report and Written Opinion for PCT/US13/61452 dated Feb. 24, 2014 in 11 pages.

Davison, J.A., Chapter 11: Intraocular Lenses, *Duane's Clinical Ophthalmology on CD-ROM*, Lippincott Willliams & Wilkins, 2005, vol. 6, pp. 1-46.

Final Office Action for U.S. Appl. No. 13/017,189 dated Jul. 18, 2014 in 10 pages.

Final Office Action for U.S. Appl. No. 13/017,189 dated Jan. 13, 2015 in 20 pages.

Final Office Action for U.S. Appl. No. 13/092,359 dated Mar. 5, 2013 in 11 pages.

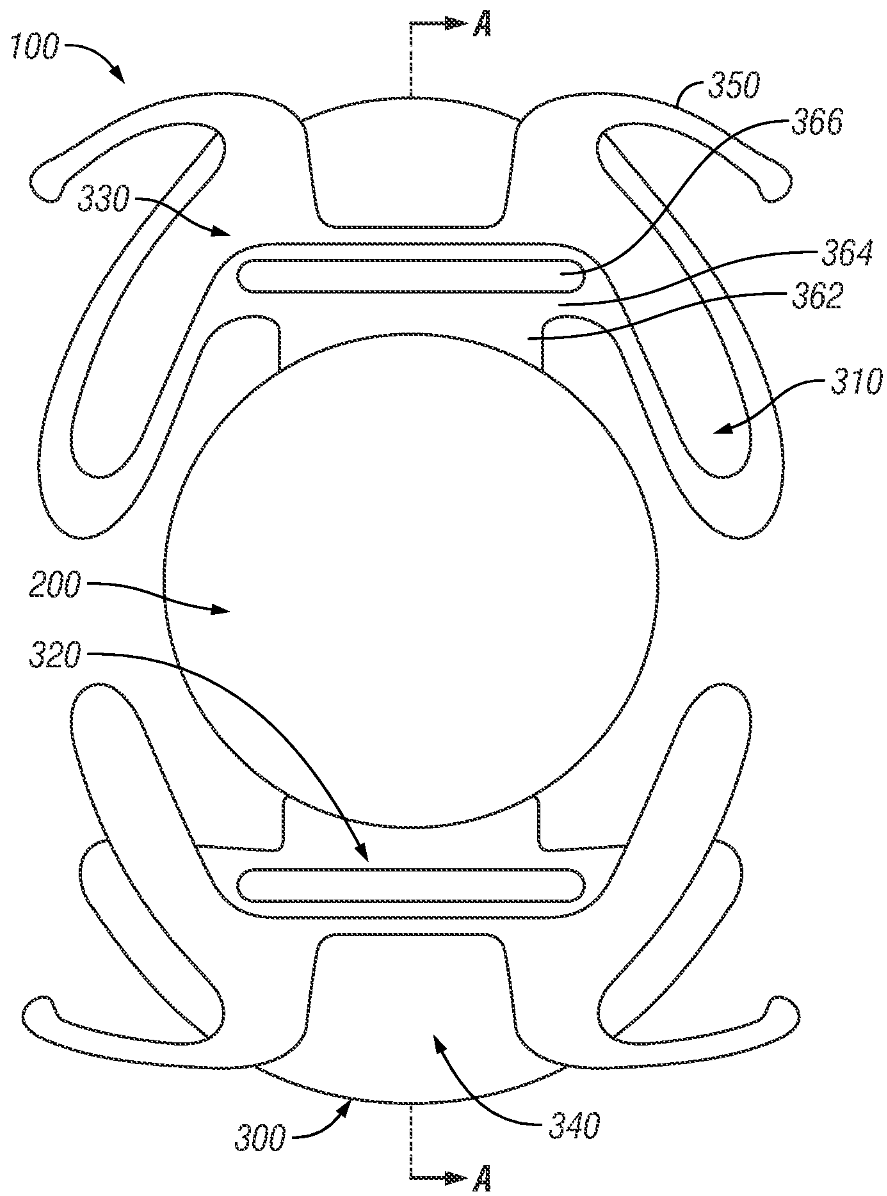
Final Office Action for U.S. Appl. No. 13/092,359 dated Feb. 6, 2015 in 21 pages.

(56) **References Cited**

OTHER PUBLICATIONS

Final Office Action for U.S. Appl. No. 13/111,599 dated May 2, 2013 in 10 pages.
Final Office Action for U.S. Appl. No. 13/111,599 dated Feb. 6, 2015 in 21 pages.
Final Office Action for U.S. Appl. No. 13/155,327 dated Dec. 10, 2012 in 10 pages.
Final Office Action for U.S. Appl. No. 13/953,605 dated Sep. 25, 2014 in 17 pages.
Final Office Action for U.S. Appl. No. 14/274,352 dated Jun. 8, 2015 in 27 pages.
Final Office Action for U.S. Appl. No. 13/891,088 dated Jul. 2, 2015 in 17 pages.
Final Office Action for U.S. Appl. No. 14/035,813 dated Sep. 30, 2015 in 26 pages.
Final Office Action for U.S. Appl. No. 14/143,612 dated Mar. 20, 2015 in 14 pages.
Final Office Action for U.S. Appl. No. 14/257,933 dated Mar. 19, 2015 in 23 pages.
First Action Interview Pre-Interview Communication for U.S. Appl. No. 14/741,230 dated Jul. 30, 2015 in 5 pages.
International Search Report and Written Opinion for PCT/US2014/072518 dated Jul. 23, 2015 in 15 pages.
Internet Archive Wayback Machine; Crystalens—Is Crystalens right for you?; downloaded from http://web.archive.org/web/20141025080709/http://crystalens.com/en-us/iscrystalensrightforyou.aspx (Archived Oct. 25, 2014; printed on Aug. 12, 2015).
Office Action for U.S. Appl. No. 13/017,189 dated May 9, 2013 in 9 pages.
Office Action for U.S. Appl. No. 13/092,359 dated Oct. 25, 2012 in 10 pages.
Office Action for U.S. Appl. No. 13/092,359 dated Sep. 8, 2014 in 15 pages.
Office Action for U.S. Appl. No. 13/092,359 dated Jun. 5, 2015 in 11 pages.
Office Action for U.S. Appl. No. 13/111,599 dated Jan. 2, 2013 in 11 pages.
Office Action for U.S. Appl. No. 13/111,599 dated Sep. 5, 2014 in 13 pages.
Office Action for U.S. Appl. No. 13/111,599 dated Jun. 26, 2015 in 12 pages.
Office Action for U.S. Appl. No. 13/155,327 dated Jul. 20, 2012 in 7 pages.
Office Action for U.S. Appl. No. 13/155,327 dated Apr. 26, 2013 in 7 pages.
Office Action for U.S. Appl. No. 14/270,166 dated Mar. 3, 2015 in 19 pages.
Office Action for U.S. Appl. No. 13/953,605 dated May 20, 2014 in 9 pages.
Office Action for U.S. Appl. No. 14/274,352 dated Feb. 12, 2015 in 10 pages.
Office Action for U.S. Appl. No. 13/891,088 dated Aug. 13, 2014 in 25 pages.
Office Action for U.S. Appl. No. 14/035,821 dated Apr. 13, 2015 in 33 pages.
Office Action for U.S. Appl. No. 14/035,813 dated Mar. 26, 2015 in 16 pages.
Office Action for U.S. Appl. No. 14/143,162 dated Aug. 4, 2014 in 18 pages.
Office Action for U.S. Appl. No. 14/143,162 dated Jul. 27, 2015 in 13 pages.
Office Action for U.S. Appl. No. 14/257,933 dated Oct. 31, 2014 in 9 pages.
Office Action for U.S. Appl. No. 14/257,933 dated Aug. 31, 2015 in 14 pages.
Response to Office Action for U.S. Appl. No. 13/017,189 dated Aug. 8, 2013 in 5 pages.
Response to Final Office Action for U.S. Appl. No. 13/017,189 dated Dec. 18, 2014 in 10 pages.
Response to Office Action for U.S. Appl. No. 13/092,359 dated Jan. 31, 2013 in 8 pages.
Response to Final Office Action for U.S. Appl. No. 13/092,359 dated Jul. 29, 2013 in 7 pages.
Response to Final Office Action for U.S. Appl. No. 13/092,359 dated Jan. 8, 2015 in 9 pages.
Response to Final Office Action for U.S. Appl. No. 13/092,359 dated May 6, 2015 in 9 pages.
Response to Office Action for U.S. Appl. No. 13/111,599 dated Apr. 9, 2013 in 6 pages.
Response to Office Action for U.S. Appl. No. 13/111,599 dated Jul. 30, 2013 in 6 pages.
Response to Final Office Action for U.S. Appl. No. 13/111,599 dated Jan. 6, 2015 in 13 pages.
Response to Office Action for U.S. Appl. No. 13/111,599 dated Jun. 8, 2015 in 12 pages.
Response to Office Action for U.S. Appl. No. 13/155,327 dated Oct. 26, 2012 in 5 pages.
Response to Office Action for U.S. Appl. No. 13/155,327 dated Apr. 10, 2013 in 5 pages.
Response to Office Action for U.S. Appl. No. 13/155,327 dated Jul. 25, 2013 in 5 pages.
Response to Office Action for U.S. Appl. No. 13/953,605 dated Aug. 19, 2014 in 7 pages.
Response to Final Office Action for U.S. Appl. No. 13/953,605 dated Dec. 18, 2014 in 12 pages.
Response to Office Action for U.S. Appl. No. 14/274,352 dated May 12, 2015 in 10 pages.
Response to Office Action for U.S. Appl. No. 13/891,088 dated Dec. 15, 2014 in 8 pages.
Response to Office Action for U.S. Appl. No. 14/035,821 dated Oct. 12, 2015 in 15 pages.
Response to Office Action for U.S. Appl. No. 14/035,813 dated Jul. 27, 2015 in 10 pages.
Response to Office Action for U.S. Appl. No. 14/143,612 dated Jan. 5, 2015 in 8 pages.
Response to Office Action for U.S. Appl. No. 14/143,612 dated Jul. 17, 2015 in 8 pages.
Response to Office Action for U.S. Appl. No. 14/257,933 dated Feb. 2, 2015 in 10 pages.
Response to Office Action for U.S. Appl. No. 14/257,933 dated Jul. 17, 2015 in 10 pages.

* cited by examiner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INTRAOCULAR LENS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based on U.S. Provisional Application No. 61/689,394, filed on Jun. 5, 2011, the contents and disclosures of which are fully incorporated herein by reference.

BACKGROUND OF THE INVENTION

Premium intraocular lenses (IOLs) implanted during cataract surgery are categorized three ways: accommodating, multifocal and toric intraocular lenses.

The best visual acuity is achieved with the single focus accommodating lenses. The optic of these lenses moves forward and backward upon constriction and relaxation of the ciliary muscle. However, for reading in dim lighting conditions, or for small print, week reading glasses are often necessary.

The multifocal lenses focus light on the retina at either two or three focal lengths. Thus, there is more than one image on the retina simultaneously. This creates problems since the amount of light in focus is divided between the multiple focal points, and contrast sensitivity is thereby reduced, making vision at all distances difficult in dim lighting. In addition, there are severe problems when driving at night when the pupil is dilated. Many patients experience severe glare and halos and many have had to have the multifocal lenses explanted and replaced with a single vision standard lens, because of this problem. However, the near vision with the multifocal lenses is superior to that of the current accommodating lens.

The toric lenses correct the eyes that have significant astigmatism.

The currently marketed plate accommodating intraocular lenses provide excellent distance and intermediate vision but sometimes require weak, +1.00, reading glasses for prolonged reading, for seeing small print, or reading in dim lighting conditions.

Furthermore, it is important for intraocular lenses to have a consistent location along the axis of the eye to provide good uncorrected distance vision and to center in the middle of the vertical meridian of the eye. Without excellent uncorrected distance vision there is no point in implanting lenses designed to give seamless vision from far to near.

The original intraocular lens consisted of a single optic. These lenses frequently de-centered and dislocated and it was discovered that there was a need to center and fixate the lens optic in the vertical meridian of the eye.

Attachments to the optic that center and fixate the lens within the capsular bag are called haptics. Traditionally, haptics consist of multiple flexible loops of various designs, J loops, C loops, closed loops and flexible radial arms. Recently, traditional haptics have been replaced in some lens designs with oblong, flat flexible plates, called plate haptics. These plate haptics usually made from silicone, are solid, flat, flexible and between 3.0 and 6.0 mm in width, 0.20 to 0.75 mm thick, and may have tapered, rounded or parallel sides. Plate haptics often have flexible loops or fingers that help center and fixate the lens within the capsular bag. These flexible fingers extend beyond the distal or outer end of the plate haptics and slightly beyond the diameter of the capsular bag and are designed to flex centrally to center and fixate the lens and its optic within the capsular bag.

An intraocular lens (IOL) is a lens implanted into the eye, usually replacing a normal human lens that has been clouded over by a cataract, or can replace a normal human lens as a form of refractive surgery to change the eye's optical power.

An accommodating IOL (AIOL) permits refocusing of the eye by means of movement along the optical axis in response to the constriction or relaxation of ciliary muscles. Near vision results from a forward movement of the optic upon constriction of the ciliary muscle which increases the pressure in the posterior part of the eye with a simultaneous decrease in pressure in the anterior part of the eye. Distance vision results from the reverse pressure change that takes place upon relaxation of the ciliary muscle and the resultant backwards movement of the lens. The movement of the optic enables the patient implanted with the lens to automatically change their vision between far, intermediate and near.

AIOLs are known to consist of opposing haptics positioned on either side of a lens optic. Once a patient's cataract is removed, e.g. by phacoemulsification, the AIOL is placed into the empty capsular bag. The haptics help to center the AIOL and fixate it within the capsular bag by fibrosis. Such AIOLs are described in U.S. Pat. Nos. 5,674,282, 5,476,514, and 5,496,366, to Cumming, herein incorporated by reference in its entirety.

And although current AIOLs provide patients with significantly restored distance and intermediate vision, adequate near vision is commonly lacking—often requiring that patients use weak reading glasses to enhance near vision. Multi-focal and toric lens solutions suffer from the disadvantages identified above.

SUMMARY OF THE INVENTION

An intraocular lens according to an embodiment of the present invention is described that overcomes the deficiencies of present designs noted above.

The field of the invention is an intraocular lens that provides seamless vision from distance to near.

An intraocular lens is provided comprising a lens optic coupled to at least one haptic and a torsion bar positioned between the lens optic and the at least one haptic.

The intraocular lens may comprise, for example, an intraocular lens for improving vision wherein the intraocular lens is configured for implantation in a capsular bag of a patient. The lens comprises: a single focus, biconvex optic and a pair of plate haptics.

The single focus, biconvex optic comprises an optical material. The optic has a circular configuration configured to be centered about an optical axis of the eye when implanted. The lens has a longitudinal axis defining a length dimension of the lens and a transverse axis defining a width dimension of the lens, both of which are orthogonal to the optical axis of the eye when implanted. The transverse axis of the lens is perpendicular to the longitudinal axis of the lens. The optic has a first side and a second side. The first side of the optic and the second side of the optic are on opposite sides of the transverse axis of the lens.

One of the plate haptics is coupled to the first side of the optic, and the other plate haptic is coupled to the second side of the optic. The longitudinal axis of the lens extends through the optic and the pair of haptics. Each plate haptic comprises a proximal end and a distal end, a frame, and a pair of opposing lateral paddles. The proximal end is closer to the optic than the distal end. Each plate haptic comprises a haptic material. The frame is embedded within the haptic material. The frame comprises a different material that is more rigid than the haptic material to provide longitudinal rigidity to the haptic. The pair of opposing lateral paddles are configured to stabilize the lens to prevent the intraocular lens from tilting.

The pair of lateral paddles form bilateral extensions of the haptic to at least partially surround the optic. The pair of lateral paddles are configured to locate the optic in a posterior position along the optical axis of the eye when implanted. The more rigid material of the frame extends into each lateral paddle to provide longitudinal rigidity to the pair of lateral paddles and the plate haptic. The haptics are configured to vault posteriorly in response to an end-to-end compressive force from the capsular bag such that the paddles are posterior to the distal ends of the haptics, the paddles being configured to apply force on the vitreous cavity. Each plate haptic is flexibly coupled to the optic by a haptic coupling system. The haptic coupling system comprises a strap, a transverse slot, and a connecting bar. The strap is coupled to the optic. An elongate axis of the strap is substantially perpendicular to the longitudinal axis of the lens. A length of the strap is measured along the elongate axis of the strap. The transverse slot extends completely through the haptic coupling system. The transverse slot is distal to the strap. An elongate axis of the slot is substantially perpendicular to the longitudinal axis of the lens. A length of the slot measured along its elongate axis is between 2.0 mm and 5.0 mm. The connecting bar is distal to the strap and proximal to the elongate slot such that the connecting bar is between the strap and the elongate slot. The longitudinal axis of the lens extends through the strap, the connecting bar, and the slot. The connecting bar extends laterally from one of the lateral paddles to the other of the lateral paddles. Each of the connecting bars is configured to stretch and twist upon the end-to-end compressive force from the capsular bag to position the optic posteriorly in the capsular bag upon implantation.

Other features and advantages of the present invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the presently described apparatus and method of its use.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

Illustrated in the accompanying drawing(s) is at least one of the best mode embodiments of the present invention In such drawing(s):

FIG. **1** illustrates a top plan view of an AIOL according to at least one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The above described drawing figures illustrate the described invention in at least one of its preferred, best mode embodiment, which is further defined in detail in the following description. Those having ordinary skill in the art may be able to make alterations and modifications to what is described herein without departing from its spirit and scope. Therefore, it should be understood that what is illustrated is set forth only for the purposes of example and should not be taken as a limitation on the scope of the present invention.

A preferred embodiment will now be described with reference to FIG. **1**.

An accommodating intraocular lens (AIOL) **100** comprises: an optic **200** coupled to at least one haptic **300**.

The AIOL **100** is placed into the capsular bag of a patient's eye after cataract surgery via known techniques such as, for example, phacoemulsification. The lens is centered so that the optical axis of the lens coincides with that of the patient's eye. The haptics **300** contact the capsular bag and the natural fibrosis of the tissue secures the haptics **300**, and consequently the AIOL **100**, in place.

The optic **200** is preferably a single focus optic that gathers the incoming light and focuses it on the retina of the patient so as to effect vision. The optic **200** may be bioconvex, refractive, diffractive, plano-convex, Fresnell, spheric, aspheric, toric, or of any other type that is substantially single focus. In order to permit the optic **200** to be inserted into the eye through a small incision, the optic **200** is preferably made of a flexible optical material, such as, for example, silicone, acrylic, hydrogel, or other flexible optical material now known or hereafter developed.

The at least one haptic **300** comprises a proximal end **320** opposite a distal end **340**. The proximal end **320** is flexibly coupled to a periphery of the optic **200**. In at least one embodiment, the AIOL **100** comprises opposing haptics positioned linearly along a longitudinal axis A of the AIOL **100**.

The haptic body may be substantially flexible in the transverse direction and substantially rigid in the longitudinal direction so as to enable the AIOL **100** to be folded and inserted into the eye via a small incision. One of ordinary skill will appreciate that while substantial rigidity may promote vaulting; the degree of rigidity imposed is not intended to preclude an effective vault of the optic. It is preferable that the haptic be constructed of the same or similar flexible material as the optic, including, but not limited to: silicone, hydrogel, acrylic, or similar material.

The plate haptic **300** may comprise opposing lateral paddles **310**, the haptic and paddles operable to engage, fixate and center the haptic into the capsular bag. Such exemplary haptics and paddles are discussed in U.S. Pat. Nos. 13/017,189; 13/092,359; 13/111,599; and 13/155,327; 13/472,893; and 13/472,354, incorporated herein by reference in their entireties.

A frame **330** may be embedded within the haptic **300** so as to promote the longitudinal rigidity thereof. The frame may be formed of polyimide, prolene, polymethylmethanylate (PMMA), titanium, or similar material. The frame may be a meshwork of rigid material molded into the flexible material and/or a lattice of such material. Such exemplary frames are discussed in U.S. Pat. Nos. 13/017,189; 13/092,359; 13/111,599; and 13/155,327; 13/472,893; and 13/472,354, incorporated herein by reference in their entireties.

The haptic **300** may further comprise projections **350**, or fingers, extending from the distal end to engage the capsular bag and secure and center the AIOL thereto. The projections may be homogeneous with the frame and may be made of either polyimide, PMMA, acrylic or any other inert material. Such exemplary projections are discussed in U.S. Pat. Nos. 13/017,189; 13/092,359; 13/111,599; and 13/155,327; 13/472,893; and 13/472,354, incorporated herein by reference in their entireties.

The proximal end **320** of the haptic **300** may be coupled to the optic via connecting portion **360** that operates to permit contraction of the ciliary muscles to cause an end-to-end compression of opposing haptics with an increase in vitreous pressure, thus moving the optic substantially forward. The connecting portion **360** preferably comprises a strap **362** adjacent the optic periphery and flexibly coupled thereto, a torsion bar **364** adjacent the strap opposite the optic, and an elongate slot **366** adjacent the torsion bar opposite the strap. Accordingly, the strap, torsion bar and slot are arranged linearly along the longitudinal axis of the AIOL.

The strap **362** couples the optic to the haptic and is preferably of the same material as the haptic. The strap assists in accommodation in that they decrease the resistance to the pressure that pushes the optic forward. Exemplary straps are described in U.S. Pat. Nos. 13/017,189; 13/092,359; 13/111,599; and 13/155,327; 13/472,893; and 13/472,354, incorporated herein by reference in their entireties.

The torsion bar **364** extends laterally between opposing paddles of the haptic. Moreover, the torsion bar is preferably integral to the haptic at each of the lateral ends (with respect to the longitudinal axis A) of the torsion bar, and is preferably of the same flexible material as the haptic. However, the torsion bar may also be of a different material than the haptic such that the torsion bar is substantially more rigid or more flexible than the haptic. As mentioned above, the torsion bar is adjacent the strap at one longitudinal end (with respect to the longitudinal axis A), and adjacent the elongate slot. In at least one embodiment, the torsion bar may be from 0.1 to 2.0 mm in length. Preferably, the torsion bar has a circular cross-section, but all cross-sectional shapes are specifically contemplated.

The elongate slot **366** is an aperture formed in the haptic that extends laterally and parallel to the torsion bar and partially separating the torsion bar from the balance of the haptic. Preferably, the slot comprises an oval shape, but all shapes are specifically contemplated. As mentioned above, the slot is adjacent the torsion bar distal to the optic. Preferably, the slot dimensions ranging from 0.1 to 0.5 mm in height and 2.0 to 5.0 mm in length.

On insertion into the eye, the haptics are vaulted posteriorly. The haptics move centrally and posteriorly in response to ciliary muscle contraction, i.e. end-to-end compression. Such movement, combined with the change in vitreous pressure, causes the optic to vault anteriorly and the haptics to vault centrally and posteriorly to further increase the pressure in the posterior vitreous cavity of the eye. This increase in pressure is further facilitated by the paddles dipping posteriorly into the vitreous cavity, thereby causing the optic to move forward. This effect is further facilitated by the stretching and/or rotation of the torsion bars in response to the movement. Relaxation of the ciliary muscle causes an increase in the diameter of the ciliary muscle and a reduction in vitreous cavity pressure with an increase in pressure in the anterior part of the eye such that the optic **200** moves posteriorly to the distant vision position.

In at least one embodiment, the longitudinal length of the AIOL (i.e. from distal end to distal end) may be between approximately 9.0-11.0 mm, with the diameter as measured from the tips of the lateral projections being between approximately 11.5-12.0 mm. The haptics are preferably between 3.0-6.0 mm wide and 0.20-0.75 mm thick, while the optic may be approximately 5.0 mm.

The enablements described in detail above are considered novel over the prior art of record and are considered critical to the operation of at least one aspect of the invention and to the achievement of the above described objectives. The words used in this specification to describe the instant embodiments are to be understood not only in the sense of their commonly defined meanings, but to include by special definition in this specification: structure, material or acts beyond the scope of the commonly defined meanings Thus if an element can be understood in the context of this specification as including more than one meaning, then its use must be understood as being generic to all possible meanings supported by the specification and by the word or words describing the element.

The definitions of the words or drawing elements described herein are meant to include not only the combination of elements which are literally set forth, but all equivalent structure, material or acts for performing substantially the same function in substantially the same way to obtain substantially the same result. In this sense it is therefore contemplated that an equivalent substitution of two or more elements may be made for any one of the elements described and its various embodiments or that a single element may be substituted for two or more elements in a claim.

Changes from the claimed subject matter as viewed by a person with ordinary skill in the art, now known or later devised, are expressly contemplated as being equivalents within the scope intended and its various embodiments. Therefore, obvious substitutions now or later known to one with ordinary skill in the art are defined to be within the scope of the defined elements. This disclosure is thus meant to be understood to include what is specifically illustrated and described above, what is conceptually equivalent, what can be obviously substituted, and also what incorporates the essential ideas.

The scope of this description is to be interpreted only in conjunction with the appended claims and it is made clear, here, that the named inventor believes that the claimed subject matter is what is intended to be patented.

What is claimed is:

1. An intraocular lens for improving vision, the intraocular lens configured for implantation in a capsular bag of an eye of a patient, the lens comprising:

a single focus, biconvex optic comprising an optical material, the optic having a circular configuration configured to be centered about an optical axis of the eye when implanted, the lens having a longitudinal axis defining a length dimension of the lens and a transverse axis defining a width dimension of the lens, both of which are orthogonal to the optical axis of the eye when implanted, the transverse axis of the lens being perpendicular to the longitudinal axis of the lens, the optic having a first side and a second side, the first side of the optic and the second side of the optic being on opposite sides of the transverse axis of the lens;

a pair of plate haptics, one of the plate haptics coupled to the first side of the optic and the other plate haptic coupled to the second side of the optic, the longitudinal axis of the lens extending through the optic and the pair of haptics, each plate haptic comprising:

a proximal end and a distal end, the proximal end being closer to the optic than the distal end, each plate haptic comprising a haptic material;

a frame embedded within the haptic material, the frame comprising a different material that is more rigid than the haptic material to provide longitudinal rigidity to the haptic; and

a pair of opposing lateral paddles that are configured to stabilize the lens to prevent the intraocular lens from tilting, the pair of lateral paddles forming bilateral extensions of the haptic to at least partially surround the optic, the pair of lateral paddles configured to locate the optic in a posterior position along the optical axis of the eye when implanted;

wherein the more rigid material of the frame extends into each lateral paddle to provide longitudinal rigidity to the pair of lateral paddles and the plate haptic;

wherein the haptics are configured to vault posteriorly in response to an end-to-end compressive force from the capsular bag such that the paddles are posterior to the distal ends of the haptics, the paddles being configured to apply force on the vitreous cavity;

wherein each plate haptic is flexibly coupled to the optic by a haptic coupling system comprising:

a strap coupled to the optic, an elongate axis of the strap being substantially perpendicular to the longitudinal axis of the lens, a length of the strap measured along the elongate axis of the strap;

a transverse slot extending completely through the haptic coupling system, the transverse slot being distal to the strap, an elongate axis of the slot being substantially perpendicular to the longitudinal axis of the lens, a length of the slot measured along its elongate axis being between 2.0 mm and 5.0 mm; and

a connecting bar distal to the strap and proximal to the elongate slot such that the connecting bar is between the strap and the elongate slot, the longitudinal axis of the lens extends through the strap, the connecting bar, and the slot, the connecting bar extending laterally from one of the lateral paddles to the other of the lateral paddles,

wherein each of the connecting bars is configured to stretch and twist upon the end-to-end compressive force from the capsular bag to position the optic posteriorly in the capsular bag upon implantation.

2. The intraocular lens of claim **1**, wherein the haptic material and the optic comprise a same material.

3. The intraocular lens of claim **2**, wherein the same material is acrylic.

4. The intraocular lens of claim **2**, wherein the same material is silicone.

5. The intraocular lens of claim **1**, wherein each frame is shaped to make its respective plate haptic more flexible about a longitudinal axis of the plate haptic than about a transverse axis of the plate haptic to enable the intraocular lens to be folded and inserted into the eye, the longitudinal axis of the plate haptic being perpendicular to the transverse axis of the plate haptic and collinear with the longitudinal axis of the lens, and wherein the transverse axis of the haptic is parallel to the transverse axis of the lens.

6. The intraocular lens of claim **1**, wherein each frame comprises polyimide.

7. The intraocular lens of claim **1**, wherein each frame comprises PMMA.

8. The intraocular lens of claim **1**, wherein the length dimension of the lens is between 9.0 mm and 11.0 mm.

9. The intraocular lens of claim **1** wherein each haptic and associated pair of lateral paddles are contiguous and form a structure which is more flexible about a longitudinal axis of the structure than about its transverse axis, wherein the longitudinal axis of the structure is co-linear with the longitudinal axis of the lens.

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